ENT. VIII(813) : BIOECOLOGY AND CONTROL OF MARGINAL GALL FORMING THRIPS *LIOTHRIPS KARNYI* BAGNALL INFESTING BLACK PEPPER
(1984 - 1991)

FINAL REPORT

भाकृअनुप
ICAR

NATIONAL RESEARCH CENTRE FOR SPICES
(Indian Council of Agricultural Research)
CALICUT - 673 012,KERALA

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FINAL REPORT

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3. Name and address of Research Institute/Centre : National Research Centre for Spices
Marikunnu P.O.
CALICUT-673 012

4. Project title : Bioecology and control of marginal gall forming thrips Liothrips karnyi Bagnall infesting black pepper

5. Name and designation of project leader : S. Devasahayam
Scientist (Selection Grade)

6. Name and designation of project leader and associate and work to be done

Sl. no.	Name and designation	Time spent	Work done
1.	S. Devasahayam-Project leader Scientist (Selection Grade)	60 man months	All items

7. Location of research project with complete address (Division/Section/Sub Centre) : Entomology Section
National Research Centre for Spices
Marikunnu P.O.
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8. Date of start : January 1984

9. Date of termination : March 1991

10. a) Objectives

The project aims at studying the biology and ecology of gall thrips Liothrips karnyi infesting black pepper with a view to evolve suitable control measures against the pest.

b) Practical utility including background information

Black pepper, the dried mature berries of Piper nigrum L. is a major source of foreign exchange for the country among agricultural produces. However, though India is a leading producer of black pepper in the world, the productivity of the crop is considerably low. Infestation by insect pests is one of the factors responsible for the low productivity. Among the various insects recorded on the crop in India, the gall thrips Liothrips karnyi has been identified as a persistent pest in Kerala (Visalakshi and Joseph, 1967). Banerjee et al. (1981) reported that they were the most important pest of black pepper in South Wynad in Kerala. The adult thrips were described by Ananthakrishnan (1960). Raman and Ananthakrishnan (1983) described the anatomical changes induced by the pest infestation on leaves. Visalakshi and Joseph (1967) conducted preliminary studies on the nature of damage and biology of the pest. The natural enemies recorded on the pest include Montandoniola moraguesi (Anthocoridae) and Androthrips flavipes (Phlaeothripidae) (Ananthakrishnan, 1978). Very few field trials have been conducted for control of gall thrips. Preliminary trials conducted by Nair and Christudas (1976) indicated that among the five insecticides evaluated, monocrotophos 0.02% was the most effective followed by dimethoate 0.03% and phosphamidon 0.05%. Vivekanandan et al.(1981) reported that among the six insecticides tested, fenvalerate and methamidophos were relatively more effective in controlling the pest infestation.

Thus, the information available on the distribution of the pest in various areas, its life cycle, seasonal abundance, natural enemies and their interactions with the pest and control measures, is scanty. The proposed project would provide information on the fore-mentioned aspects including formulation of effective control measures against the pest, thus increasing the productivity of the crop.

11. Technical programme

a) Survey for distribution of gall thrips in major black pepper areas.
b) Studies on nature of damage and biology of gall thrips.
c) Studies on seasonal population of gall thrips.
d) Studies on natural enemies of gall thrips.
e) Studies on other fauna associated with thrip galls.
f) Relative susceptibility of black pepper germplasm to gall thrips.
g) Bioassay of insecticides against gall thrips.
h) Field trials with insecticides for control of gall thrips.

12. Materials and methods

a) Distribution

Surveys were conducted at Trivandrum, Quilon, Kottayam, Idukki, Trichur, Palghat, Malappuram, Calicut, Wynad, Cannanore and Kasaragod districts in Kerala; South Kanara, North Kanara, Shimoga and Coorg districts in Karnataka and Kanyakumari and Nilgiris districts in Tamil Nadu to record the incidence of gall thrips in major black pepper areas. Three gardens were surveyed in each location and 15 vines were selected at random in each garden. The incidence of infested leaves was recorded on 25 leaves selected at random from the bottom, middle and top portions of each vine. Correlations between the incidence of gall thrips and altitude of the location and variety were also worked out.

b) Nature of damage and biology

The nature of damage with particular reference to morphological aberrations caused by gall thrips was studied in detail. The morphometrics of various stages was determined using occular and stage micrometers under a stereomicroscope. For studies on life history, virgin males and females were released on tender leaves containing galls and placed in glass chimney cages after removal of existing eggs and other stages of gall thrips present in them. The galls were carefully opened at regular intervals to observe the progress in development of various stages, under a stereomicroscope .

c) Seasonal population

The seasonal population of gall thrips was recorded at monthly intervals at Kalpetta (Wynad district). Leaf galls were collected every month at random from vines (var.Panniyur-I) and brought to the laboratory. The galls were opened carefully without disturbing the individuals and the number of eggs, juveniles and adults were counted under a stereomicroscope.

d) Natural enemies

i) Identification: Leaf galls of black pepper were collected from various locations (during the survey for the incidence of gall thrips) and brought to the laboratory and the natural enemies identified.

ii) Predatory potential: The predatory potential of important natural enemies viz., Montandoniola moraguesi and Androthrips flavipes was determined. In the case of M. moraguesi, adults and nymphs were placed individually in glass vials and a known number of II stage larvae of gall thrips were introduced. The number of prey consumed by the predator was determined at 12 h intervals. In the case of A. flavipes, adults and larvae were placed individually in glass vials and a known number of eggs of gall thrips were introduced. The number of eggs consumed by the predator was determined at 12 h intervals.

iii) Life history : Eggs of M. moraguesi and A. flavipes were observed for hatching and the newly hatched nymphs and larvae were transferred to glass vials. II stage larvae and eggs of gall thrips were provided as food material for these two predators, respectively, and the development of various stages was observed at regular intervals under a stereomicroscope.

iv) Effect of insecticides : The effect of monocrotophos (0.05%) and dimethoate (0.05%) on adults of M. moraguesi and A. flavipes was studied under greenhouse conditions. Rooted black pepper cuttings were sprayed with the test insecticides. Leaves of the sprayed plants were clipped off at 2 day intervals and placed in test tubes into which the adult predators were released. The predators were removed after 6 h and their mortality was recorded after 24 h.

v) Propagation of M. moraguesi : The feasibility of propagating M. moraguesi on black pepper and Mimusops elangii infested by L. karnyi and Arrhennothrips ramakrishnae, respectively, was studied. The plants were raised in pots and artificially infested by these thrips and predators to observe its establishment and multiplication.

e) Other fauna

The other fauna associated with thrip galls were identified and their occurrence noted throughout the year in relation to the age of the gall. The interrelationships between various fauna were also studied.

f) Susceptibility of germplasm

Six month old rooted cuttings of 132 accessions of black pepper cultivars were screened for natural infestation by gall thrips in the nursery. Four cuttings were maintained per accession and the percentage of leaves infested by gall thrips was recorded.

g) Bioassay of insecticides

The residual toxicity of nine insecticides viz., dimethoate, formothion, monocrotophos, phosphamidon, dichlorvos, endosulfan, methyl parathion, quinalphos (0.05% each) and malathion (0.1%) was determined under greenhouse conditions. Rooted cuttings of black pepper were sprayed with commercial formulations of the test insecticides. There were 10 treatments including a control and each treatment was replicated four times. A single leaf was clipped off

from each plant at 1,3,7,14,21,28,35,42 and 49 days after treatment and placed in test tubes; adult gall thrips were introduced into the tubes and their mortality was recorded after 24 h. The corrected percentages of mortality was calculated using Abbotts formula (Abbott,1925). The PT (Persistence x Toxicity) values were also calculated (Pradhan and Venkataraman, 1962).

h) Field trial

A field trial to evaluate the efficacy of six insecticides viz., endosulfan, quinalphos, dimethoate, monocrotophos, phosphamidon (0.05% each) and malathion (0.1%) was conducted at Kuppadi (Wynad district) in a six year old black pepper plantation. A Randomised Block Design was adopted with a plot size of three vines per treatment and replicated thrice. The insecticides were sprayed during July coinciding with emergence of new flushes. An untreated control was also maintained. The percentages of leaves infested by the pest under various treatments was determined 15 and 30 days after treatment. The trials were conducted for three years and the data subjected to pooled analysis.

Results and discussion

a) Distribution

The survey for the incidence of gall thrips on black pepper was carried out in 116 locations. The incidence of the pest was relatively higher at Idukki, Wynad, Trivandrum, Shimoga, Coorg and Nilgiris districts (Table 1).

A significant and positive correlation existed between pest incidence and altitude of the location. The incidence of gall thrips among various cultivars showed the following trend : Wynad local = Kalluvally = Arakulam munda > Karimunda = Panniyur-I > Vellamunda.

Table 1. Incidence of gall thrips on black pepper

District	% leaf infestation (range)	Altitude (m)
Kerala		
Kasaragod	0.6 - 2.0	0-50
Cannanore	0.0 - 1.3	0-100
Calicut	0.1 - 0.9	0-50
Wynad	7.0 - 16.4	750-950
Malappuram	0.0 - 0.3	0-75
Palghat	0.0 - 1.0	0-100
Trichur	0.0 - 0.3	0
Kottayam	0.0 - 1.2	100
Idukki	2.2 - 9.6	600-850
Quilon	2.9 - 7.7	225-325
Trivandrum	1.0 - 11.1	0-850
Karnataka		
Shimoga	8.1 - 9.6	600-625
North Kanara	0.5 - 5.0	75-600
South Kanara	0.0 - 3.3	50-125
Coorg	1.2 - 12.7	900-975
Tamil Nadu		
Nilgiris	8.1 - 11.3	800-950
Kanyakumari	3.6 - 6.6	300-800

b) Biology

i) Nature of damage

The morphological aberrations caused by gall thrips infestation on leaves were studied. The galls were of hypophyllous laminar fold/roll gall type, both types occurring in the same leaf. The margins of affected leaves were considerably thickened (540 - 1079 microns) at the gall region when compared to that of normal leaves (211 - 329 microns). The other changes induced by gall thrips infestation included crinkling of leaf surface, reduction in leaf size, loss in flacidity, formation of depressions and necrotic patches within the galls and yellowing around the gall region.

ii) Biology

The morphometrics of various stages and life cycle of gall thrips was studied (Tables 2 and 3).

c) Seasonal population

Studies on seasonal population of gall thrips conducted at Kalpetta (Wynad district) indicated that the pest population was high during June - September. Studies on increase in number of gall thrips within a leaf in relation to its age indicated that maximum number of individuals occurred in galls that were about 2 months old.

d) Natural enemies

i) Identification

The following natural enemies were recorded on gall thrips.

1. Geogarypus sp. (Pseudoscorpiones : Geogarypidae)
   Predaceous on larvae and pupae

2. Montandoniola moraguesi Puton (Heteroptera : Anthocoridae)
   Predaceous on all stages

Table 2. Morphometrics of gall thrips

Stage	Character			
	Length	Width	Length of antenna	Length of tube
Egg	0.33 - 0.38	0.15 - 0.17		
Larva I	0.63 - 0.85	0.20 - 0.25	0.19 - 0.20	0.08 - 0.09
Larva II	1.55 - 1.90	0.38 - 0.53	0.28 - 0.29	0.13 - 0.15
Pre pupa	1.80 - 1.90	0.43 - 0.40	0.11 - 0.13	0.15 - 0.16
Pupa I	1.85 - 2.10	0.43 - 0.48	0.20 - 0.25	0.15 - 0.18
Pupa II	2.10 - 2.20	0.45 - 0.48	0.34 - 0.35	0.19 - 0.21
Adult	1.70 - 2.38	0.36 - 0.43	0.40 - 0.46	0.16 - 0.20

n = 5
Values indicate ranges in mm

Table 3. Life cycle of gall thrips

Stage	Duration (days)
Egg	5 - 8
Larva I	5 - 7
Larva II	4 - 6
Pre pupa	1 - 2
Pupa I	1 - 2
Pupa II	2

n = 5
Values indicate range

3. Androthrips flavipes Karny (Thysanoptera : Phlaeothripidae)
   Predaceous on eggs and juveniles

4. Lestodiplosis sp. (Diptera : Cecidomyiidae)
   Larvae predaceous on juveniles

5. Rhodesiella sp. (Diptera : Chloropidae)
   Larvae predaceous on juveniles

Among the natural enemies, M. moraguesi and A. flavipes were important and widely distributed. The other three predators were recorded for the first time on gall thrips.

ii) Predatory potential

Adults and IV instar nymphs of M. moraguesi fed on all stages of gall thrips though larvae and pupae were preferred. Early instar nymphs (I and II) fed on eggs, larvae and pupae though eggs and larvae were preferred. Though M. moraguesi did not ctively search for its prey, location of prey was easy since both were confined to a limited space within the gall. The various developmental stages of M. moraguesi showed variation in consumption of prey (Table 4). Late instar nymphs (IV and V) consumed more prey than earlier instars (I,II and III). Adults fed on 5-8, 3-5 and 2-4 individuals of adults, pupae and larvae of thrips, respectively, per day.

Adults and larvae of A flavipes generally fed on eggs and juvenile stages of gall thrips though eggs were preferred. Adults consumed more prey than larvae per day; among the larvae, II stage larvae consumed more prey than I stage larvae (Table 5).

Table 4. Life cycle and predatory potential of Montandoniola moraguesi

Stage	Duration(days) Range	Mean	Prey consumed*	Mean consumption of prey per day
Egg	3 - 5	4.0		
I instar nymph	2 - 3	2.4	2 - 4	1.2
II instar nymph	2 - 3	2.6	3 - 5	1.6
III instar nymph	3 - 4	3.4	7 - 9	2.1
IV instar nymph	3 - 5	4.2	9 - 13	2.5
V instar nymph	4 - 6	5.0	14 - 18	3.3

n = 5
*Prey = larva II of gall thrips

Table 5. Life cycle and predatory potential of Androthrips flavipes

Stage	Duration (days)	Prey consumed per day*
Egg	5 - 7	
Larva I	3 - 5	2 - 4
Larva II	3 - 4	4 - 7
Pre pupa	1	
Pupa I	1 - 2	
Pupa II	2	
Adult		4 - 8

n = 5
*Prey = eggs of gall thrips

iii) Life history

The life cycle of M. moraguesi from egg - adult was completed in 19-23 days (mean 21.6 days) (Table 4). Females oviposited the eggs within the tissues in the gall region. The life cycle of A. flavipes from egg to adult was completed in 15 - 18 days (mean 17.0 days) (Table 5). Females deposited the eggs in groups among the eggs of gall thrips.

iv) Effect of insecticides

Monocrotophos 0.05% and dimethoate 0.05% (recommended against gall thrips) were toxic to M. moraguesi up to 3 days after treatment. The insecticides were toxic to A. flavipes up to 5 and 3 days, respectively, after treatment (Table 6).

v) Propagation of M. moraguesi

The feasibility of propagating M. moraguesi on rooted cuttings of black pepper was attempted. The cuttings were maintained in pots and the tender flushes were inoculated with adult gall thrips. Field collected adults of the predator were released on the galls, a month after establishment of gall thrips population. Though the predator oviposited within the galls, the same were damaged during examination due to its closed nature affecting the multiplication of the predator.

Thrip galls of other plant species were also examined to detect the presence of M. moraguesi in them. The predator was observed in leaf galls of Mimusops elangii induced by Arrhenothrips ramakrishnae. Seedlings of M. elangii were raised in pots and the tender leaves were inoculated with adult gall thrips. The predator was released on the galls a month after establishment of the prey population. However, the growth of the plants was very slow hindering the availability of sufficient number of galls for multiplication of the predator.

Table 6. Effect of insecticides on natural enemies

Treatment	% mortality				
	12 hat	1 dat	2 dat	3 dat	5 dat
Montandoniola moraguesi					
Monocrotophos 0.05%	100	100	60	20	
Dimethoate 0.05%	100	100	50	5	
Androthrips flavipes					
Monocrotophos 0.05%	100	100	80	50	15
Dimethoate 0.05%	100	100	70	30	

n = 10
dat = days after treatment
hat = hours after treatment

e) Other fauna associated with thrip galls

Leaf galls of black pepper offered an unique micro habitat for inhabitation by a wide variety of other fauna during different stages of its development. These included primary consumers of gall tissues, their natural enemies, detritus feeders and other fauna that made their appearance at a later stage when the galls became senescent (Table 7).

f) Relative susceptibility of germplasm

One hundred and thirty two accessions of rooted cuttings(6 month old) of black pepper maintained in the nursery were screened for natural infestation by gall thrips. The percentage of infested leaves in various accessions ranged between 0.0 - 31.6. Thirty one accessions were free of pest infestation (Table 8). However, the differences were not significant probably because the number of leaves available on the cuttings were few and hence there were wide variations among the replications.

g) Bioassay of insecticides

The residual toxicity of nine insecticides were evaluated against gall thrips under green house conditions (Table 9). Initial toxicity was maximum in monocrotophos which caused 90 per cent mortality up to 14 days after treatment followed by formothion, phosphamidon, dimethoate and endosulfan which caused 90 per cent mortality up to 7 days. Monocrotophos continued to cause 50 per cent mortality up to 28 days after treatment; endosulfan and malathion caused 50 per cent mortality up to 21 days. Residual toxicity was maximum in monocrotophos and malathion which caused some mortality up to 42 days after treatment. The prolonged residual toxicity of monocrotophos and malathion was also evident from their high values of PT (Persistence x Toxicity), being 2853.06 and 2525.38, respectively.

Table 7. Fauna associated with leaf galls of black pepper

Species and category
Primary consumers of gall tissues
Hypoaspis sp. (Laelapidae, Acarina)
Abrolophus sp. (Erythraeidae, Acarina)
Scheloribates sp. (Oribatulidae, Acarina)
Zygoribatula sp. (Oribatulidae, Acarina)
Pseudococcus longispinus (Pseudococcidae, Hemiptera)
Planococcus sp. (Pseudococcidae, Hemiptera)
Aspidiotus destructor (Diaspididae, Hemiptera)
Lepidosaphes piperis (Diaspididae, Hemiptera)
Chaetanaphothrips sp. (Thripidae, Thysanoptera)
Thrips sp. (Thripidae, Thysanoptera)
Assara sp. (Pyralidae, Lepidoptera)
Natural enemies of primary consumers
Geogarypus sp. (Geogarypidae, Pseudoscorpiones)
Bdella sp.(Bdellidae, Acarina)
Montandoniola moraguesi (Anthocoridae, Hemiptera)
Androthrips flavipes (Phlaeothripidae, Thysanoptera)
Aleurodothrips fasciapennis (Phlaeothripidae, Thysanoptera)
Karnyothrips melaleucus (Phlaeothripidae, Thysanoptera)
Lestodiplosis sp.(Cecidomyiidae, Diptera)
Rhodesiella sp. (Chloropidae, Diptera)
Encarsia lounsburyi (Aphelinidae, Hymenoptera)
Leptacis sp. (Platygasteridae, Hymenoptera)
Detritus feeders
Unidentified (Acarina)
Unidentified (Psocoptera)
Cortinicara gibbosa (Lathridiidae, Coleoptera)
Other fauna
Clubiona sp. (Clubionidae, Araneae)
Technomyrmex sp. (Formicidae, Hymenoptera)
T. albipes (Formicidae, Hymenoptera)
Plagiolepis sp. (Formicidae, Hymenoptera)
Dolichoderus sp. (Formicidae, Hymenoptera)

Table 8. Incidence of gall thrips on black pepper accessions in the nursery

Range of leaf infestation (%)	No. of accessions
0	31
0.1 - 10.0	36
10.1 - 20.0	54
20.1 - 30.0	10
30.1 - 40.0	1

Table 9. Residual toxicity of insecticides to gall thrips

Treatment	No. of days for which 90 percent mortality observed	No. of days for which 50 percent mortality observed	No. of days for which some mortality observed(P)	Mean mortality (T)	PT index
Dimethoate 0.05%	7	14	35	60.90	2131.50
Formothion 0.05%	7	14	35	58.79	2057.65
Monocrotophos 0.05%	14	28	42	67.93	2853.06
Phosphamidon 0.05%	7	14	28	69.77	1953.56
Dichlorvos 0.05%	0	3	28	37.00	1036.00
Endosulfan 0.05%	7	21	35	70.56	2469.60
Malathion 0.1%	3	21	42	60.14	2525.38
Methyl parathion 0.05%	3	3	35	46.24	1618.40
Quinalphos 0.05%	3	14	35	52.97	1853.95

Table 10. Effect of insecticides on control of gall thrips on black pepper (combined analysis of three years data)

Treatment	Mean percentage of infested leaves	
	15 dat	30 dat
Endosulfan 0.05%	5.6 (13.68)	20.6 (27.01)
Malathion 0.1%	9.4 (17.91)	21.1 (27.35)
Quinalphos 0.05%	9.9 (18.37)	22.7 (28.48)
Dimethoate 0.05%	3.2 (10.38)	16.8 (24.20)
Monocrotophos 0.05%	4.1 (11.66)	12.0 (20.27)
Phosphamidon 0.05%	9.3 (17.73)	21.3 (27.52)
Control	24.2 (29.50)	26.4 (30.95)
CD at 5% level	4.02	2.2

Figures in parentheses are transformed values
dat = days after treatment

h) Field control trial

The relative efficacy of six insecticides was evaluated for the control of gall thrips in the field (Table 10). The percentage of infested leaves was significantly less in all treatments as compared to control, 15 and 30 days after treatment. At the end of 15 days after treatment, dimethoate was significantly superior to phosphamidon, malathion and quinalphos and was on par with monocrotophos and endosulfan. Plots treated with dimethoate had the lowest percentage of infested leaves followed by those treated with monocrotophos. At the end of 30 days after treatment, monocrotophos was significantly superior to all the treatments. Plots treated with monocrotophos had the lowest percentage of infested leaves followed by those treated with dimethoate.

The trials indicated that spraying of monocorotophos or dimethoate 0.05% could be recommended for control of gall thrips. The first spray is to be given during June/July coinciding with the emergence of new flushes. A second spray may be given after 25-30 days in case the infestation persists.

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VIVEKANANDAN, P.,REGUPATHY, A., HABEEBULAH, B., BALASUBRAMANIAN, M. and IRULAPPAN, I. 1981. Dissipation of insecticides in black pepper applied to control leaf gall thrips Liothrips karnyi Bagnall. Indian Spices 18 (2-4): 25,27-29.

13. Approximate expenditure incurred in the project (give reasons for variation if any, from original estimated cost)

Original estimate : Rs. 1,45,750
Revised estimate : Rs. 2,45,000

The project which was originally proposed for three years was extended for four more years. There was escalation in the salary of scientific and other staff also.

14. Publications and material (one copy each to be supplied with this proforma) developed

a) Research papers

i) DEVASAHAYAM, S. 1989. Residual toxicity of certain insecticides to leaf gall thrips (Liothrips karnyi Bagnall) on black pepper. Entomon **14** : 79-80.

ii) DEVASAHAYAM, S. 1990. Field evaluation of six insecticides for the control of leaf gall thrips (Liothrips karnyi Bagnall) on black pepper. Entomon **15** : 137 - 138.

iii) DEVASAHAYAM, S. 1991. Montandoniola moraguesi Puton (Heteroptera - Anthocoridae) - a potential biocontrol agent of Liothrips karnyi Bagnall (Phlaeothripidae : Thysanoptera) infesting black pepper. In : Abstract of papers, National Seminar on Biological Control in Plantation Crops, 27-28 July 1991, Kottayam. p.11.

iv) DEVASAHAYAM, S., PREMKUMAR, T. and ABDULLA KOYA, K.M. 1988. Insect pests of black pepper Piper nigrum L. in India - a review. J. Plant. Crops **16** : 1-11.

b) Popular articles

i) PREMKUMAR, T. and DEVASAHAYAM, S. 1988. Management of insect pests for higher yields in black pepper. Indian Cocoa, Arecanut & Spices J. **11** : 121-122.

ii) PREMKUMAR, T. and DEVASAHAYAM, S. 1989. Control of pests of black pepper. Indian Fmg. **38** (10) : 33, 34 & 35.

c) Reports

Nil